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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/698,170	10/30/2003	Sei-Hyung Ryu	5308-279	2502
20792	7590	10/31/2006	EXAMINER	
MYERS BIGEL SIBLEY & SAJOVEC PO BOX 37428 RALEIGH, NC 27627			TRAN, LONG K	
			ART UNIT	PAPER NUMBER
			2818	

DATE MAILED: 10/31/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

## Office Action Summary

Application No.

10/698,170

Applicant(s)

RYU, SEI-HYUNG

Examiner

Long K. Tran

Art Unit

2818

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 10 August 2006.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1,5-19,21-27,29,30 and 61-87 is/are pending in the application.
- 4a) Of the above claim(s) 61-87 is/are withdrawn from consideration.
- 5) ☒ Claim(s) 1,5-14,27,29 and 30 is/are allowed.
- 6) ☒ Claim(s) 15-19,21-26 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application
- 6) ☐ Other: \_\_\_\_\_

## **DETAILED ACTION**

### ***Response to Amendment***

1. This office action is in response to Amendment filed on 08/10/2006.
2. Claims **2 – 4, 20, 28** and **31 – 60** have been cancelled.
3. Claims **1, 11, 15, 21** and **24** have been amended.
4. Claims **61 – 87** have been added.
5. Newly submitted claims **61 – 87** are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons: the original claims recite a silicon carbide metal-oxide semiconductor field effect transistor cell, comprising: an n-type limiting region disposed on the drift layer beneath and between peripheral edges of first region of p-type silicon carbide as shown in figures 2A, 3 – 5D, while the new claims recite a drift layer is in proximity to the floor and sidewall of the first p-type silicon carbide region as shown in figure 2B.
6. Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claims **61 – 87** are withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.
7. Claims **1, 5 – 19, 21 – 27** and **29 – 30** are presented for examination.

### ***Response to Arguments***

8. Applicant's arguments with respect to claims 1 – 30 have been considered but are moot in view of the new ground(s) of rejection.

9. The Affidavit filed on 08/10/2006 under 37 CFR 1.131 is sufficient to overcome the 6,700,156 reference after thoroughly reviewing the provisional application no. 60/435,212.

### ***Drawings***

10. Figure 1 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g). Corrected drawings in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

### ***Claim Rejections - 35 USC § 102***

11. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

12. Claims **15, 16, 18, 19, 22 and 23** are rejected under 35 U.S.C. 102(e) as being anticipated by Saitoh et al. (US Patent Application Publication No. 2003/0209741).

13. Regarding claim 15, Saitoh, figures 1, 4, 5 discloses a silicon carbide metal-oxide semiconductor field effect transistor (MOSFET) comprising:

a drift layer of n-type silicon carbide (11);

first regions (12) of p-type silicon carbide adjacent the drift layer (11);

a first region of n-type silicon carbide (11b) disposed between peripheral edges of the first regions (12) of p-type silicon carbide;

second regions of  $n^+$ -type silicon carbide (13) within the first regions of p-type silicon carbide (12), wherein the second regions of  $n^+$ -type silicon carbide have a carrier concentration greater than a carrier concentration ( $n^-$ ) of the drift layer and are spaced apart from the peripheral edges of the first regions of p-type silicon carbide (12);

an oxide layer (13) on the drift layer, the first region of n-type silicon carbide (11b) and the second regions of n-type silicon carbide (13);

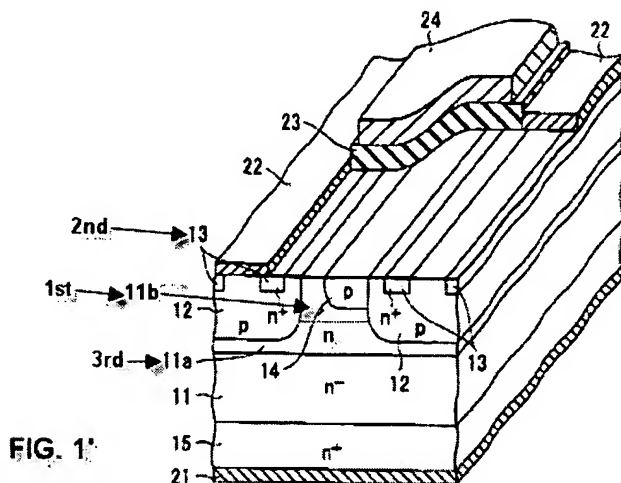
third regions of n-type silicon carbide (11a) disposed beneath the first regions of p-type silicon carbide (12) and between the first regions of p-type silicon carbide (12) and the drift layer (11), wherein the third regions of n-type silicon carbide (11a) have a carrier concentration ( $n$ ) greater than the carrier concentration ( $n^-$ ) of the drift layer (11), and wherein the first region of n-type silicon carbide ((11b); ( $n$ )) has a higher carrier than a carrier concentration of the drift layer ((11), ( $n^-$ )) and has a lower carrier

source contacts (22) on portions of the second regions (13) of n-type silicon carbide;

a gate contact (24) on the oxide layer (23) ; and

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Drain contact (21) on the drift layer (11; column 5, lines 36 – 51) opposite the oxide layer (23).



Regarding claim 16, Saitoh discloses the third regions of n-type silicon carbide are adjacent the peripheral edges of the first regions of p-type silicon carbide (12).

Regarding claim 18, Saitoh discloses the first region of n-type silicon carbide (11b) comprise a region of the drift layer ((11); figure 5).

Regarding claim 19, Saitoh discloses the n-type limiting (third) silicon carbide regions (11a) comprising implanted n-type regions in the drift layer ([0081]).

Regarding claim 22, Saitoh discloses an n-type silicon carbide layer (15) between the drift layer (11) and the drain contact (21), wherein the n-type silicon carbide layer has a higher carrier concentration ( $n^+$ ) than the carrier concentration ( $n^-$ ) of the drift layer (11).

Regarding claim **23**, Saitoh discloses the n-type silicon carbide layer (15) comprises an n-type silicon carbide substrate ([0053]).

***Claim Rejections - 35 USC § 103***

14. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

15. Claims **25** and **26** are rejected under 35 U.S.C. 103(a) as being unpatentable over Saitoh et al. (US Application Publication No. 2003/0209741).

16. Regarding claims **25** and **26**, Saitoh discloses all limitations of claim 1 or 15 but fails to teach the limiting (third) regions of n-type silicon carbide have a thickness of from about 0.5 to about 1.5 micrometers and a carrier concentration of from  $1 \times 10^{15}$  to about  $5 \times 10^{17} \text{ cm}^{-3}$ .

However, it would have been well known in the art that the selection of those parameters such as **energy, concentration, temperature, time, molar fraction, depth, thickness, etc.**, would have been obvious and involve routine optimization which has been held to be within the level of ordinary skill in the art. "Normally, it is to be expected that a change in **energy, concentration, temperature, time, molar fraction, depth, thickness, etc., or in combination of the parameters** would be an unpatentable modification. Under some circumstances, however, changes such as these may impart

patentability to a process if the particular ranges claimed produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art ... such ranges are termed "critical ranges and the applicant has the burden of proving such criticality.... More particularly, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.

17. Claim **21** is rejected under 35 U.S.C. 103(a) as being unpatentable over Saitoh et al. (US Patent Application Publication No. 2003/0209741) in view of Ryu et al. ((US Patent Application Publication No. 2002/0038891).

18. Regarding claim **21**, Saitoh discloses a silicon carbide metal-oxide semiconductor field effect transistor (MOSFET) comprising:

- a drift layer of n-type silicon carbide (11);

- first regions (12) of p-type silicon carbide adjacent the drift layer (11);

- a first region of n-type silicon carbide ((11b); Examiner modified FIG. 1') disposed between peripheral edges of the first regions (12) of p-type silicon carbide;

- second regions of  $n^+$ -type silicon carbide (13) within the first regions of p-type silicon carbide (12), wherein the second regions of  $n^+$ -type silicon carbide have a carrier concentration greater than a carrier concentration ( $n^-$ ) of the drift layer and are spaced apart from the peripheral edges of the first regions of p-type silicon carbide (12);

- an oxide layer (13) on the drift layer, the first region of n-type silicon carbide (11b) and the second regions of n-type silicon carbide (13);



third regions of n-type silicon carbide (11a) disposed beneath the first regions of p-type silicon carbide (12) and between the first regions of p-type silicon carbide (12) and the drift layer (11), wherein the third regions of n-type silicon carbide (11a) have a carrier concentration (n) greater than the carrier concentration ( $n^-$ ) of the drift layer (11), and wherein the first region of n-type silicon carbide ((11b); (n)) has a higher carrier than a carrier concentration of the drift layer ((11), ( $n^-$ ));

source contacts (22) on portions of the second regions (13) of n-type silicon carbide;

a gate contact (24) on the oxide layer (23) ; and

Drain contact (21) on the drift layer (11; column 5, lines 36 – 51) opposite the oxide layer (23).

Saitoh fails to teach an n-type epitaxial layer of silicon carbide on the first p-type regions (12) and the first region of n-type silicon carbide (11b).

However, Ryu, figure 7, discloses an n-type epitaxial silicon carbide ((26'')/(27)/(26'')) on the p-type regions (20) and an n-type silicon carbide ((12a); examiner modified figure 17' below) to reduce the surface roughness created by implant activation anneal ([0062]).

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to provide the Saitoh's device with the n-type epitaxial layer of silicon carbide of Saitoh, in order to reduce damage which may enable higher channel mobility ([0062]).

19. Claims **15**, **17**, **21** and **24** are rejected under 35 U.S.C. 103(a) as being obvious over Ryu et al. (US Patent Application Publication No. 2002/0038891 in view of Saitoh et al. (US Patent Publication No. 2003/0209741.

20. Regarding to claims **15** and **21**, Ryu, in figures 1B, 7 and 9H, discloses a silicon carbide metal-oxide semiconductor field effect transistor (MOSFET) comprising:

a drift layer of n-type silicon carbide (12);

first regions of p-type silicon carbide (20) adjacent the drift layer (12) ;

regions of n<sup>+</sup>-type silicon carbide (N<sup>+</sup>) within the first regions of p-type silicon carbide, wherein the second regions of N<sup>+</sup>-type silicon carbide have a carrier concentration greater than a carrier concentration (N<sup>-</sup>) of the drift layer and are spaced apart from the peripheral edges of the first regions of p-type silicon carbide;

an n-type epitaxial layer of silicon carbide ((26')/(27)/(26')); [0062]); on the first p-type silicon carbide (20) and the first n-type region (12a);

an oxide layer on the drift layer, the first region of n-type silicon carbide and the second regions of n-type silicon carbide;

source contacts ((Source), (30')) on portions of the second regions of n-type silicon carbide;

a gate contact ((Gate), (32)) on the oxide layer (28); and

drain contact ((Drain); (34)) on the drift layer opposite the oxide layer.

Ryu fails to teach a first region of n-type silicon carbide disposed between peripheral edges of the first regions of p-type silicon carbide; and regions of n-type silicon carbide disposed beneath the first regions of p-type silicon carbide and between

the first regions of p-type silicon carbide and the drift layer, wherein the third regions of n-type silicon carbide have a carrier concentration greater than the carrier concentration of the drift layer.

However, Saitoh discloses a similar MOSFET to the claimed invention including (first) regions of n-type silicon carbide ((11b); Examiner modified FIG. 1') disposed between peripheral edges of the first regions of p-type silicon carbide; and (third) regions of n-type silicon carbide (11a) disposed beneath the first regions of p-type silicon carbide (12) and between the first regions of p-type silicon carbide (12) and the drift layer (11), wherein the (third) regions of n-type silicon carbide (11a) have a carrier concentration ( $n$ ) greater than the carrier concentration ( $n^-$ ) of the drift layer (11) to prevent resistance from expanding to the broad  $n^-$ -type drift layer (11) from JFET region interposed between the p-type base layer (12). See paragraph [0066]

It would have been obvious to one of ordinary skill in the art at the time of the invention was made to provide the MOSFET of Ryu with the n-type silicon carbide disposed between peripheral edges of the first regions p-type the n-type silicon carbide and the regions of n-type silicon carbide (11a) disposed beneath the first regions of p-type silicon carbide of Saitoh, in order to reduce the resistance between adjacent p-type base layer.

Regarding claim 17, the combined Ryu and Saitoh device appears to include an n-type region comprising an epitaxial layer silicon carbide on drift layer on the drift layer; and the first regions of p-type silicon carbide are formed in the n-type silicon carbide epitaxial layer.

Regarding claim **24**, the combined Ryu and Saitoh device includes a second p-type silicon carbide region disposed within the first p-type silicon carbide region adjacent to the first n-type silicon carbide region (Ryu, figure 1B).

***Allowable Subject Matter***

21. Claims **1, 5 - 14, 27, 29** and **30** are allowed.
22. The following is an examiner's statement of reasons for allowance: Claims **1, 5 - 14, 27, 29** and **30** are allowable over the prior art of record because none of the prior art whether taken singularly or in combination, especially when these limitations are considered within the specific combination claimed, to teach:

An n-type silicon carbide limiting region disposed between a drift layer and a p-type silicon carbide region, wherein the limiting region comprising a first portion disposed in close proximity to a floor of the p-type silicon carbide region and a second portion disposed in close proximity to a side wall of the p-type silicon region, wherein the n-type limiting region has carrier concentration that is greater than a carrier concentration of the drift layer, and wherein the first portion has carrier concentration greater than a carrier concentration of the second portion as cited in the independent claims 1 and 27; an n-type epitaxial layer on the first p-type silicon carbide and a portion of a first n-type region within the p-type silicon region and disposed between the first n-type silicon carbide region and the p-type silicon carbide region and an oxide layer; and among other limitations as cited in the independent claims 1, 11 and 27.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably

accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

***Conclusion***

23. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

24. A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Long K. Tran whose telephone number is 571-272-1797. The examiner can normally be reached on Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, MinSun Harvey or Matthew Smith can be reached on 571-272-1835 or 571-272-1907 (Smith). The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Long Tran *LT*

October 30, 2006

*Anders Nuyss*  
Primary Examiner